

WHAT IS CLAIMED IS:

1                    1.        A method of epitaxially growing a multi-layer device in a single  
2 epitaxial run utilizing HVPE techniques, the method comprising the steps of:  
3                    locating a first Group III source within an HVPE reactor;  
4                    locating a second Group III source within said HVPE reactor;  
5                    heating said first Group III source to a first temperature;  
6                    heating said second Group III source to a second temperature;  
7                    heating a first growth zone of said HVPE reactor to a third temperature;  
8                    heating a second growth zone of said HVPE reactor to a fourth  
9 temperature, wherein said first and second growth zones are different growth zones;  
10                   locating a substrate within said first growth zone;  
11                   reacting said first Group III source with a halide gas to form a first Group  
12 III reactant;  
13                   reacting said second Group III source with said halide gas to form a  
14 second Group III reactant;  
15                   transporting said first Group III reactant to said first growth zone;  
16                   transporting a reaction gas to said first growth zone, said reaction gas  
17 containing nitrogen;  
18                   reacting said first Group III reactant with said reaction gas to grow a first  
19 Group III nitride layer of a first thickness on said substrate;  
20                   transferring said substrate to said second growth zone, wherein a  
21 temperature corresponding to said substrate varies by less than 200° C during the  
22 transferring step;  
23                   transporting said second Group III reactant to said second growth zone;  
24                   transporting said reaction gas to said second growth zone; and  
25                   reacting said second Group III reactant with said reaction gas to grow a  
26 second Group III nitride layer of a second thickness on said first Group III nitride layer  
27 substrate.

1                   2.       The method of claim 1, further comprising the step of transferring  
2       said substrate to a growth interruption zone maintained at a fifth temperature prior to the  
3       step of transferring said substrate to said second growth zone.

1                   3.       The method of claim 2, further comprising the step of directing an  
2       inert gas in a flow direction that substantially prevents said first Group III reactant, said  
3       second Group III reactant, and said reaction gas from entering said growth interruption  
4       zone.

1                   4.       The method of claim 1, further comprising the step of stabilizing  
2       the reaction between said second Group III reactant and said reaction gas prior to  
3       performing said step of transferring said substrate from said first growth zone to said  
4       second growth zone.

1                   5.       The method of claim 2, further comprising the step of stabilizing  
2       the reaction between said second Group III reactant and said reaction gas prior to  
3       transferring said substrate from said growth interruption zone to said second growth zone.

1                   6.       The method of claim 1, wherein the temperature corresponding to  
2       said substrate varies by less than 100° C during the transferring step.

1                   7.       The method of claim 1, wherein the temperature corresponding to  
2       said substrate varies by less than 50° C during the transferring step.

1                   8.       The method of claim 1, wherein the temperature corresponding to  
2       said substrate varies by less than 10° C during the transferring step.

1                   9.       The method of claim 1, wherein the first thickness of said first  
2       Group III nitride layer is greater than 1 micron and the second thickness of said second  
3       Group III nitride layer is less than 1 micron.

1                   10.      The method of claim 1, wherein the first thickness of said first  
2       Group III nitride layer is greater than 2 microns and the second thickness of said second  
3       Group III nitride layer is less than 1 micron.

1                    11.     The method of claim 1, wherein the first thickness of said first  
2     Group III nitride layer is greater than 5 microns and the second thickness of said second  
3     Group III nitride layer is less than 1 micron.

1                    12.     The method of claim 3, wherein said flow direction of said inert  
2     gas is substantially orthogonal to a source flow direction.

1                    13.     The method of claim 3, wherein said flow direction of said inert  
2     gas is substantially opposite to a source flow direction.

1                    14.     The method of claim 3, wherein said flow direction of said inert  
2     gas is at an oblique angle to a growth surface of said substrate.

1                    15.     The method of claim 1, further comprising the steps of:  
2                    locating a third Group III source within said HVPE reactor;  
3                    heating said third Group III source to a fifth temperature;  
4                    reacting said third Group III source with said halide gas to form a third  
5     Group III reactant;  
6                    transporting said third Group III reactant to said first growth zone; and  
7                    reacting said third Group III reactant with said reaction gas, wherein said  
8     first Group III nitride layer is comprised of both said first and third Group III sources.

1                    16.     The method of claim 15, further comprising the steps of:  
2                    locating a fourth Group III source within said HVPE reactor;  
3                    heating said fourth Group III source to a sixth temperature;  
4                    reacting said fourth Group III source with said halide gas to form a fourth  
5     Group III reactant;  
6                    transporting said fourth Group III reactant to said first growth zone; and  
7                    reacting said fourth Group III reactant with said reaction gas, wherein said  
8     first Group III nitride layer is comprised of said first, third and fourth Group III sources.

1                    17.     The method of claim 1, further comprising the steps of:  
2                    locating a third Group III source within said HVPE reactor;  
3                    heating said third Group III source to a fifth temperature;

4                    reacting said third Group III source with said halide gas to form a third  
5 Group III reactant;  
6                    transporting said third Group III reactant to said second growth zone; and  
7                    reacting said third Group III reactant with said reaction gas, wherein said  
8 second Group III nitride layer is comprised of both said second and third Group III  
9 sources.

1                    18.    The method of claim 1, further comprising the steps of:  
2                    locating a fourth Group III source within said HVPE reactor;  
3                    heating said fourth Group III source to a sixth temperature;  
4                    reacting said fourth Group III source with said halide gas to form a fourth  
5 Group III reactant;  
6                    transporting said fourth Group III reactant to said second growth zone; and  
7                    reacting said fourth Group III reactant with said reaction gas, wherein said  
8 second Group III nitride layer is comprised of said second, third and fourth Group III  
9 sources.

1                    19.    The method of claim 1, further comprising the step of growing a  
2 buffer layer on said substrate prior to said step of reacting said first Group III reactant  
3 with said reaction gas to grow a first Group III nitride layer.

1                    20.    The method of claim 19, wherein said buffer layer is comprised of  
2 a material selected from the group consisting of GaN, AlN, and aluminum oxy nitride.

1                    21.    The method of claim 1, further comprising the steps of:  
2                    heating at least one acceptor impurity metal to a fifth temperature; and  
3                    transporting said at least one acceptor impurity metal to said first growth  
4 zone, wherein said first Group III nitride layer contains said at least one acceptor impurity  
5 metal.

1                    22.    The method of claim 21, wherein said first Group III nitride layer  
2 is a p-type layer.

1                    23.    The method of claim 21, wherein said at least one acceptor  
2 impurity metal is selected from the group consisting of magnesium (Mg), zinc (Zn) and  
3 magnesium-zinc (MgZn) alloys.

1                   24.     The method of claim 21, further comprising the step of lowering a  
2     temperature corresponding to said at least one acceptor impurity metal from said fifth  
3     temperature to a sixth temperature, wherein said lowering step is performed after  
4     initiation of growth of said first Group III nitride layer and prior to said step of  
5     transferring said substrate to said second growth zone.

1                   25.     The method of claim 24, wherein said sixth temperature is  
2     approximately 10° C lower than said fifth temperature.

1                   26.     The method of claim 1, further comprising the steps of:  
2                   heating at least one acceptor impurity metal to a fifth temperature; and  
3                   transporting said at least one acceptor impurity metal to said second  
4     growth zone, wherein said second Group III nitride layer contains said at least one  
5     acceptor impurity metal.

1                   27.     The method of claim 26, wherein said second Group III nitride  
2     layer is a p-type layer.

1                   28.     The method of claim 26, wherein said at least one acceptor  
2     impurity metal is selected from the group consisting of magnesium (Mg), zinc (Zn) and  
3     magnesium-zinc (MgZn) alloys.

1                   29.     The method of claim 26, further comprising the step of lowering a  
2     temperature corresponding to said at least one acceptor impurity metal from said fifth  
3     temperature to a sixth temperature, wherein said lowering step is performed after  
4     initiation of growth of said second Group III nitride layer.

1                   30.     The method of claim 29, wherein said sixth temperature is  
2     approximately 10° C lower than said fifth temperature.

1                   31.     The method of claim 1, further comprising the step of transporting  
2     at least one donor impurity to said first growth zone, wherein said first Group III nitride  
3     layer contains said at least one donor impurity.

1                    32.     The method of claim 31, wherein said at least one donor impurity  
2 is selected from the group consisting of oxygen (O), germanium (Ge), silicon (Si) and tin  
3 (Sn).

1                    33.     The method of claim 1, further comprising the step of transporting  
2 at least one donor impurity to said second growth zone, wherein said second Group III  
3 nitride layer contains said at least one donor impurity.

1                    34.     The method of claim 33, wherein said at least one donor impurity  
2 is selected from the group consisting of oxygen (O), germanium (Ge), silicon (Si) and tin  
3 (Sn).